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GRAPEVINE FLEA-BEETLES.

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CONTENTS.

	Page.		Page.
Introduction	1	The lesser grapevine flea-beetle—Continued.	
History	2	Distribution	13
The grapevine flea-beetle	4	Food plants	13
Description of stages	4	Habits	13
Distribution	6	Life history	14
Food plants	6	Economic importance	20
Habits	7	Predatory enemies	22
Life history	7	Methods of control	23
The lesser grapevine flea-beetle	11	General summary	24
Description of stages	11	Literature cited	26

INTRODUCTION.

The grapevine flea-beetle (*Altica chalybea* Ill.) is a grape pest which, in the period of its most destructive activity in early spring, eats out the swelling buds, causing severe injury in restricted localities. It is one of the best known and most widely distributed of the insect enemies of the grape. No other is the source of so many complaints to the Bureau of Entomology, and American entomological literature is full of references to it. In general its life history is well known, yet, in spite of this, occasional discrepancies occur in accounts of its life history that have never been reconciled with the usually recorded observations. These discrepancies are usually disposed of by attributing them to the variation of individual beetles.

A study of the life history of the grapevine flea-beetle was undertaken by the writer during the season of 1916 for the purpose of comparison with that of a smaller flea-beetle also attacking grape. A close similarity between the smaller beetle and the typical species was noted, but the differences, particularly in seasonal history and habits, were so well marked and so constant that the writer was

surprised when the smaller beetle was determined as "*Altica chalybea* Ill., small form." When it was noted that the seasonal history and habits of the typical flea-beetle conformed quite closely with those usually ascribed to it, particularly by Slingerland (*19*) [1] and Hartzell (*23*, *24*), and that those of the "small form" coincided with the discrepancies mentioned above, the writer became of the opinion that two economic species had been masquerading under a single name. The existence of two species instead of one had long been suspected by Mr. E. A. Schwarz, who determined the reared material, but in the absence of biological data which would differentiate them he had not previously thought it advisable to erect a new species.

It is obvious that the confusion of two pests that are similar but have different seasonal histories may lead to a serious confusion in the application of remedial measures. It is, therefore, the purpose of this paper in the account of these two species, *Altica chalybea* Ill. and *A. woodsi*, herein described as new, to give particular attention to structure and habits by which they may be distinguished. Where each species must be treated separately, the typical grapevine flea-beetle, being the one generally known, is first considered, and the "small form" is then compared with it. The data presented are based on rearing records and field observations made at North East, Pa., during the seasons of 1916 and 1917 and miscellaneous field observations during the two seasons previous.[2]

HISTORY.

There are over 135 references to the grapevine flea-beetle in the literature of American economic entomology, a larger number of references than to any other American grape insect except the grapevine rootworm (*Fidia viticida* Walsh). Since 1859 there has been at least one reference to it each year except during the years 1866, 1873, and 1875. Most of these references no doubt apply to the typical form.

The grapevine flea-beetle was first described in 1807 by Illiger (*1*), who named it *Haltica chalybea*. It was again described by Le Conte (*2*) as *Galeruca janthina* and later by Thomas (*3*) as *Chrysomela vitivora*. Harris (*5*) in 1835 placed *C. vitivora* Thomas as a synonym of *H. chalybea* Ill., and the same year Herrick (*4*) showed that *G. janthina* Lec. was a synonym of the same species. In most of the recent literature relating to this insect it has been designated under the generic name Haltica. Woods (*25*) has recently shown that the original spelling *Altica* should be used instead of the amended form *Haltica*.

[1] Reference is made by number (italics) to "Literature cited," p. 26.

[2] During the season of 1916 the writer was assisted by Mr. James K. Primm. The writer is further indebted to Mr. J. H. Paine for the photographs used in Plates II and III and to Mr. H. K. Plank for the photograph used in Plate IV.

In the first account of the habits of the grapevine flea-beetle, Thomas recorded the destructiveness to grape buds by the adult, the feeding upon leaves by the larvæ, and the transformation through the pupal stage in the soil. Regarding these habits there has been practically no disagreement by succeeding authors. Conflicting statements have been frequently made, however, regarding the number of generations a year, the place of oviposition, and food plants.

Harris (*6*) outlined the seasonal history as follows: The emergence of adults from hibernation in April, followed by the development of immature stages, gives rise to another brood in July that are to pass through the ensuing winter. Harris called the brood of adults emerging in July a "second" brood, but he clearly meant that only one brood was produced annually. Harris's observations have been upheld by subsequent investigations, notably those of Slingerland (*19*) and Hartzell (*23*, *24*), who have made the most thorough studies of the insect. Kirkpatrick (*9*), however, says that there are several generations annually, and the statement that there are two or more broods has been frequently made by subsequent writers. Lowe (*20*) states that there is a partial second brood in New York. Slingerland (*19*) offered a reason for inferring the existence of a second brood by quoting correspondence with Lowe in which the latter stated that he had found a beetle of this species ovipositing as late as July 15. At that time many newly transformed beetles were emerging while the overwintering beetles had disappeared before the last of June. Slingerland explained this unusual record of Lowe's as a record of an exceptionally late emergence of a tardy individual.

Riley (*10*) first stated that the eggs were deposited upon the leaves, and for nearly 30 years this was the generally accepted belief and was frequently copied by subsequent writers. Accompanying his statement of the place of oviposition he describes the eggs as "orange" and "like those of the potato beetle," making it seem probable that he had observed the eggs of some other insect. Comstock (*12*), in the most complete account of the insect up to that time, also stated that the eggs were found upon the leaves, either on the upper or lower side, and gave authority to his statement by accompanying it with an accurate description of the general appearance of the egg, and stated that it was "straw colored" and averaged 0.65 mm. in length. Marlatt (*18*) also referred to them as occurring on the leaves, but on the undersides only. Slingerland (*19*) stated that the eggs were usually found in groups under bud scales and strips of bark, and this observation was confirmed by Hartzell (*23*). Both investigators state that eggs may occasionally be found on the leaves. Hartzell describes the eggs as orange or saffron colored and with an average length of 1.03 mm.

The grapevine flea-beetle has been recorded as feeding on various plants, including the following: Grape (Thomas, *3*), black alder (Harris, *7*), plum and elm (Fitch, *8*), Virginia creeper (Saunders, *11*), apple and quince (MacMillan, *14*), peach (Neal, *16*), and blue beech (Schwarz, *17*).

Of these food plants only three have been frequently listed, viz, the grape, the Virginia creeper, and the black alder. It was suggested by Lintner (*13*) that records of feeding upon black alder were probably due to a confusion of this species with *A. bimarginata*, the alder flea-beetle, which closely resembles *A. chalybea*. This view was confirmed, at least so far as Harris was concerned, by Slingerland (*19*), who found in Harris's entomological correspondence evidence that Harris's later studies convinced him that the alder flea-beetle and the grapevine flea-beetle are separate species. Hartzell (*24*) lists only cultivated grape of the Concord variety and the wild grape (*Vitis bicolor*) as food plants.

Slingerland (*19*) records a difference of opinion among growers as to what varieties of grapes are most seriously attacked by the grapevine flea-beetle, some correspondents stating that the flea-beetle preferred Concord foliage and others that it preferred the thin-leaved varieties.

In addition to the references designating the grapevine flea-beetle as *A. chalybea* Ill., Lugger (*21*) describes the habits of an insect which he calls "the lesser grapevine flea-beetle," and believed to be *A. ignita* Ill., the strawberry flea-beetle. He describes the habits as similar to those of *A. chalybea*, the only difference noted being that the former was little more than half the size of *A. chalybea*. It is quite possible that the insect referred to was the "small form" of the grapevine flea-beetle.

In discussing the "*ignita group*" of the genus Altica, Woods (*26*) mentions a beetle believed to be a new species collected on woodbine both in 1917 and in 1918, which is probably the lesser grapevine flea-beetle. He describes the salient characteristics of the adult and mentions that the eggs are deposited singly or by twos on the under surface of the leaves.

THE GRAPEVINE FLEA-BEETLE.

DESCRIPTION OF STAGES.

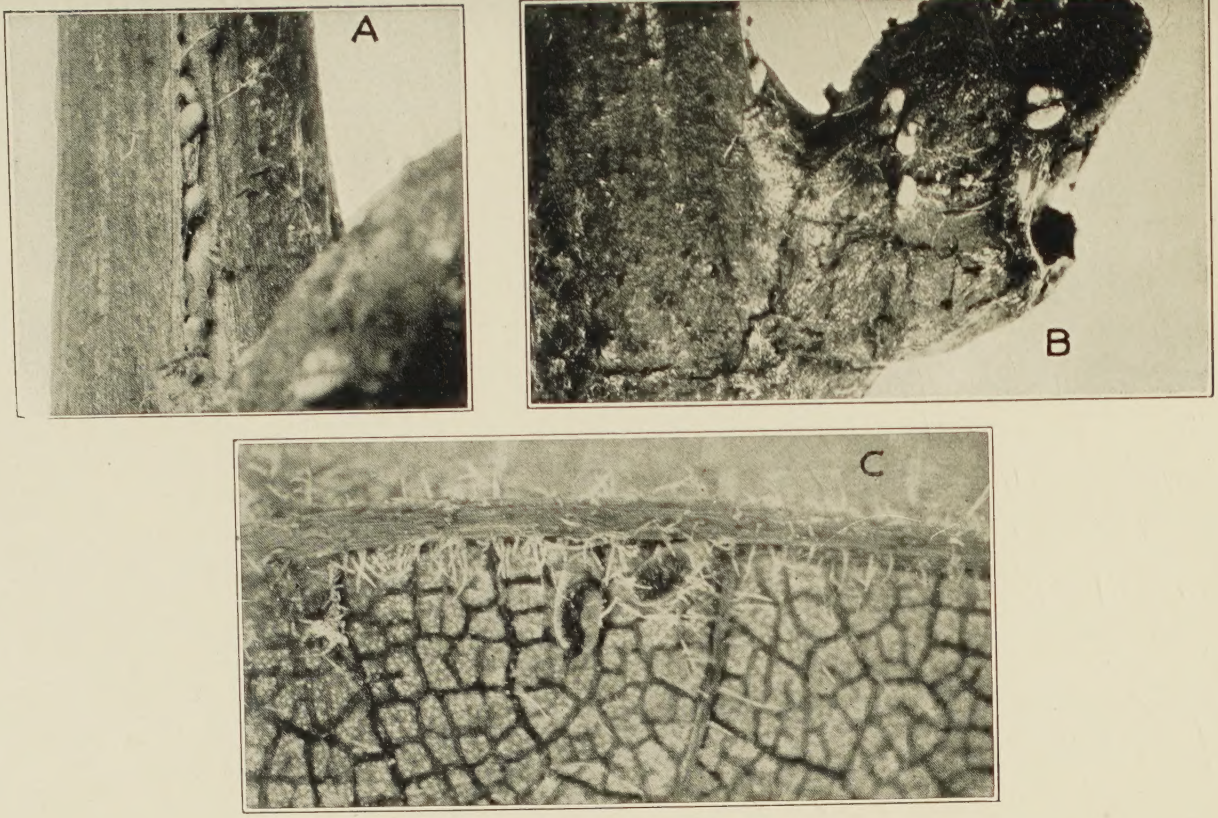
THE ADULT.

Pl. II, fig. 3.

The following is a copy of Horn's (*15*) description of the beetle:

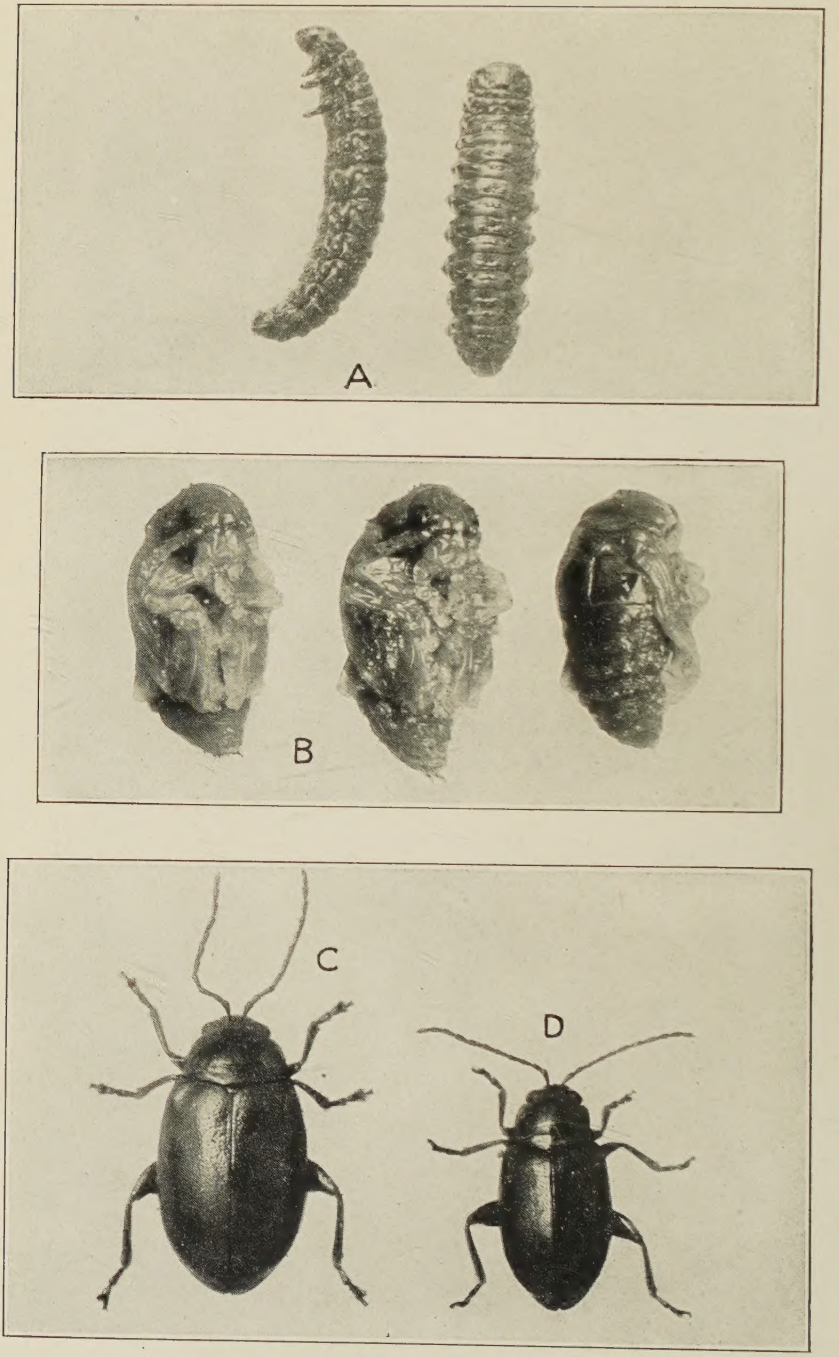
H. chalybea Illig.

Oval, of moderately robust facies, color usually metallic shining blue, rarely cupreous or greenish. Antennæ half as long as the body, piceous, the basal half with metallic lustre, joints 2–3–4 gradually longer. Head smooth, slightly rough-



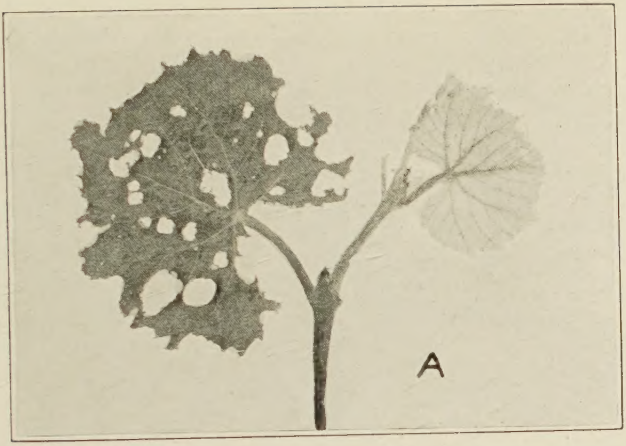
EGGS OF THE GRAPEVINE FLEA-BEETLES.

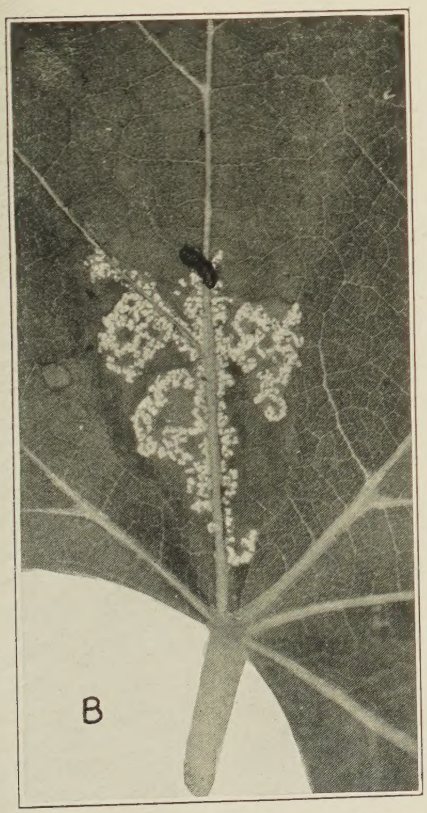
A, Eggs of *Altica chalybea* on grape cane under bark strip. *B*, Eggs of *Altica chalybea* on grape bud, bud scales removed. Bud shows feeding injury by adult beetle. *C*, Eggs of *Altica woodsi* on underside of grape leaf.

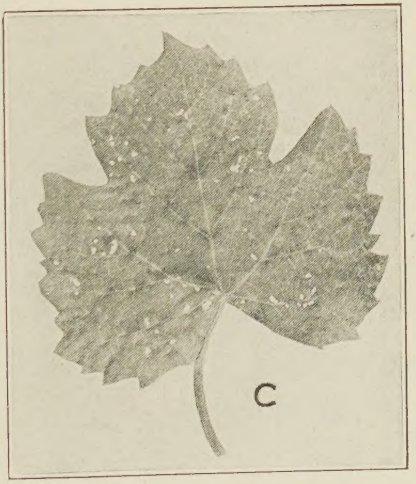


STAGES OF THE GRAPEVINE FLEA-BEETLES.

A, Mature larvæ of *Altica woodsi*. *B*, Pupæ of *Altica woodsi*. *C*, Adult of *Altica chalybea*. *D*, Adult of *Altica woodsi*.

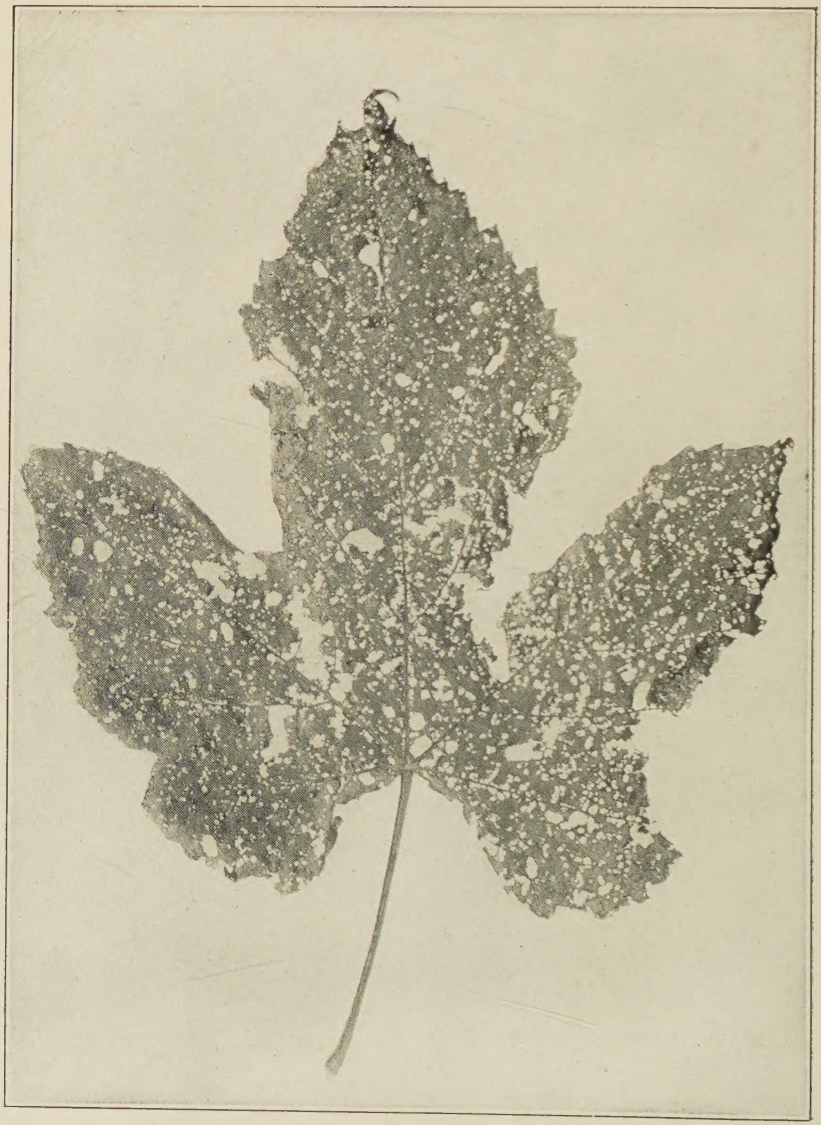






WORK OF GRAPEVINE FLEA-BEETLES.

A, Feeding marks of adult beetle of *Altica chalybea* on leaf of Concord grape. *B*, Larvæ and feeding marks of *Altica chalybea* on upper surface of grape leaf (thick-leaved variety). *C*, Feeding marks of adult beetle of *Altica chalybea* on grape leaf (thick-leaved variety).



WORK OF LESSER GRAPEVINE FLEA-BEETLE.

Feeding marks of larvæ and adults on grape (thin-leaved variety).

ened near the eyes, frontal carina rather acute, the tubercles small, oblique. Thorax a little more than half wider than long, narrowed in front, sides arcuate, margin narrow, slightly thickened in front, disc convex, the ante-basal impressed line rather deep and extending from margin to margin, surface with extremely minute scattered punctures. Elytra scarcely wider at base than the thorax, humeri rounded, umbone moderately prominent, smooth, limited within by a slight depression, surface sparsely punctate, nearly smooth near apex. Body beneath and legs blue-black, moderately shining, abdomen sparsely punctate. Length .16–.20 inch; 4–5 mm.

THE EGG.

Pl. I, A, B.

In general shape the egg is subcylindrical, with the ends rounded. The surface is roughly pitted, and on the surface opposite to the side of attachment is a twisted brownish strand about one-third the length of the egg. The color varies from a deep yellow to orange. Length 1.10 mm.; diameter 0.42 mm.

The size and color agree with the description by Hartzell (*23*) but differ from that of Comstock (*12*).

THE LARVA.

Similar to larva of *Altica woodsi*, Pl. II, A.

The larva is short and stout, convex dorsally and flattened ventrally, and is further characterized by a nearly hemispherical head, by short stout legs, and by an anus which functions as a locomotor organ. Each body segment is marked by a double series of chitinized plates or tubercles and the skin between these plates is dotted with minute wartlike excrescences. When the larva is newly hatched or molted it is yellow in color. Upon exposure to the air, however, the chitinized areas become shining black and as they fit closely together the larva itself becomes shining black. With growth the skin between the chitinized areas begins to show and when the larva is full grown the skin is so distended that a brownish yellow is the dominant color, the black being confined to the chitinized areas. The spiracles are located on the mesothoracic and first eight abdominal segments. The head and body plates are furnished with sparse, long setæ.

The arrangement of the body plates and setæ on the first seven abdominal segments is as follows: Dorsally each segment is furnished with two transverse rows of setiferous plates. The mid-dorsal plates are transversely elongate, the anterior one being slightly the longer, and are furnished with a seta on either side of the median line; on either side of each of these plates and above the spiracle are two smaller circular plates each bearing a single seta; below the spiracle is a prominent, longitudinal, compound tubercle, which roughly divides the dorsal and ventral aspects, bearing a pair of setæ, and below this is another tubercle also bearing two setæ; ventrally, near the anterior margin of the segment, there is one elongate, transverse plate crossing the median line and bearing one seta on either side; on the posterior half of the segment and at either side of the median plate is a small oval plate bearing two setæ.

On the first thoracic segment all dorsal plates are fused into one large plate, the prothoracic shield, which bears five pairs of setæ along the anterior margin, and three pairs in a row on the posterior margin; laterally there is one small tubercle bearing a single seta, and at the base of each coxa is a pair of tubercles each bearing a single seta; ventrally there is one large rectangular plate bearing an anterior and a posterior pair of setæ.

The second thoracic segment resembles the abdominal segments closely. The mid-dorsal plates are not continuous but are divided at the median line; on each side of the mid-dorsal plates is a single outer dorsal plate, the anterior one being quite

small and non-setiferous, the posterior one quite large and bearing two setæ; on each side below the outer dorsal plates is the laterally prominent compound tubercle which bears three setæ instead of two as on the abdominal segments; below the compound tubercle are two plates each bearing a single seta, the anterior one also bearing the mesothoracic spiracle; there is a pair of tubercles above each coxa, the posterior one of which bears a single seta; ventrally the arrangment of plates is similar to that of the first abdominal segment except that the posterior pair of plates bear only one seta each.

The third thoracic segment is like the second but without the spiracle.

The eighth abdominal segment is like the second, but with only one small dorsal plate on each side of the posterior mid-dorsal plate.

On the ninth thoracic segment the dorsal plates are fused into a single large one, the anal shield, which bears five pairs of setæ; ventrally there is a single elongate plate bearing two pairs of setæ.

The tenth abdominal segment is without plates or setæ.

Measurements: Width of head: First instar 0.32 mm.; second instar 0.51 mm.; third instar 0.74 mm. Average length of full grown larva 7.5 mm.

THE PUPA.

Similar to pupa of *Altica woodsi*, Pl. II, B.

In general appearance this pupa is similar to the pupa of other chrysomelid beetles, the dorsal line being strongly arcuate, the legs folded ventrally, bent so that the femora are directed away from the median line and the tibiæ toward it, the prothoracic and mesothoracic legs over the wings and the metathoracic legs under them.

Color bright yellow, appendages lighter. Antennal joints with a circlet of projections at the distal ends (four projections visible on each joint), especially conspicuous on the distal segments; elytra reaching the fifth abdominal segment, wings the sixth; spiracles borne on the mesothoracic and the first six abdominal segments; arrangement of setæ as follows: 3 pairs on head, 1 above clypeus, 1 on inner margin of the eyes, and 1 slightly above and between the eyes; on prothorax, 8 pairs; on mesothorax and metathorax, 2 pairs; on abdominal segments 1 to 8, 4 pairs in a row near the posterior dorsal margin; and on segment 9, 4 pairs around the anal hooks; 3 setæ on the distal end of each femur. Length 5 mm.

DISTRIBUTION.

The grapevine flea-beetle is found in the eastern half of the United States and in the Canadian Province of Ontario. In entomological literature and in the files of the Bureau of Entomology it has been recorded from the District of Columbia and from the following States: Massachusetts, Vermont, Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, North Carolina, Georgia, Florida, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Arkansas, Texas, Kansas, Nebraska, Colorado, and New Mexico. Some of these records may refer to the "small form."

FOOD PLANTS.

A list of food plants recorded in the literature of the species is given under history. The writer has collected it only on cultivated grapes (*Vitis* spp.), on various species of the wild grape (*Vitis* spp.), and on Virginia creeper (*Parthenocissus quinquefolia*).

HABITS.

The beetle emerges from hibernation in the spring at the time of the swelling of the grape buds, which it attacks voraciously, boring into the sides of the buds and eating out the tender parts. (Pl. I, B.) When the shoots begin to expand it eats large holes in the leaves (Pl. III, A), and often attacks the tender stems. The beetle is most voracious when newly emerged from hibernation and at that time can do an immense amount of damage.

Eggs are usually deposited on their sides, in groups, under bud scales or strips of bark, as described by Slingerland (*19*) and Hartzell (*23* and *24*). Occasionally they are placed on leaves on either the upper or the lower side.

The larvæ feed on either the upper or lower surface of thin-leaved varieties of cultivated and wild grapes, eating out large irregular holes, and often stripping out all of the leaf tissue except the leaf veins. On Concord or similar types of leaves they feed on the upper surface, leaving as feeding marks long, chain-like, whitish patches (Pl. III, B).

During the feeding period the larva molts twice. Upon becoming fully fed it burrows into the ground and forms a pupal cell a fraction of an inch below the surface. A few days are passed in the pupal cell, the prepupal period, preparatory for pupation. At the close of the pupal stage, after eclosion, the adult does not emerge at once, but remains in the cell until it is hardened and fully colored. Following emergence the beetle feeds sparingly until it goes into winter quarters. None of the specimens under observation during either season showed any tendency to copulate or oviposit during the period between transformation to the adult stage and hibernation.[1]

All stages of the beetles' activity are greatly influenced by changes in temperature. Both adults and larvæ feed more voraciously on warm days than in cold weather and on the cold days of early spring the beetles even appear to return to winter quarters. Hatching of eggs and molting of larvæ occur in the greatest numbers during the warmest part of the day.

LIFE HISTORY.

REARING METHODS.

The rearing methods used for the two species of flea-beetles were practically identical. Oviposition was secured from adults kept in battery jars or sleeve cages on grape shoots. Larvæ were reared in

[1] In addition to the insects native to the Erie-Chautauqua grape belt, upon which the foregoing account of habits and seasonal history and the following of life history are based, the writer received beetles from French Creek, W. Va., collected by Mr. Fred E. Brooks, and from Arlington, Va., collected by Mr. E. R. Selkregg, during the spring of 1917. These beetles and their offspring were reared in the insectary at North East, Pa., and their habits, seasonal history, and transformations agreed in detail with those of the native insects recorded herein.

Transformations in the pupal and pupal stages of the adult were passed in vials of the same size partially filled with earth. To determine the duration of each of these periods in the ground two methods were employed, as follows:

The first was to place a vial (lengthwise of the vial) in diameter inside of a vial 1 inch in diameter, filling the space between the two with earth. In the latter vials, here were placed and most of them were forced to form their pupal cells next to the glass sides, where their transformations could be observed readily. The outer vial was covered with black paper, which was removed only when observations were being made. The transformations of individuals in each vial was noted with a wax pencil. This method was found faulty, because of the difficulty of maintaining the normal soil moisture in so thin a layer.

It was also learned that by pressing the earth in the middle of the vial, leaving the earth at the sides comparatively loose, about half of the larvæ would form pupal cells along the sides of the glass. It was supposed, of course, for success with this method, as with the former, that the vials be covered with black paper. This method was most used in 1917.

These methods of observing transformations in the ground were developed to facilitate part of the work and the data in these transformations secured during that season are very meager. Those records for the pupation period, and those which relate to the duration of both stages are given only for 1917.

Detailed observations relative to the various properties [illegible] and began with the beginning of the larval stage in 1916.

The duration of the feeding period of the larval stage varied from 8 to 24 days, with an average of 13.3 days, as shown in Table I. The period elapsed [illegible] from August 7 to July 5.

DURATION OF PERIOD IN GROUND.

The duration of the period in the ground of 87 individuals reared varied from 11 to 24 days, with an average of 16.37 days.

The period covered by records of larvæ in the soil extended from June 10, when the first larvæ entered the ground, to July 27, when the latest adults emerged. The variation in duration of this period is shown in Table II.

EMERGENCE FROM HIBERNATION AND OVIPOSITION IN 1917

The earliest record of adult emergence is May 11, at which time grape buds were swelling. Eggs were first found May 18. Adult beetles were found on grapevines until the latter part of June, when they disappeared altogether.

TABLE II.—*Issue in ground of 4 oviposi[illegible] from June 10, 1916.*

Number of pairs issued	Duration of period
	Days.
2	15
1	16
2	17
1	18
1	19
1	20
4	21
26	22
12	23
7	24
[illegible] 87	[illegible] 20.71

[illegible] issued a stage.

INCUBATION PERIOD OF EGG

The duration of the incubation period in 1917 (see Table III) varied from 13 to 21 days, with an average of 15.18 days, as shown in Table III. The period covered by records on the incubation period extended from May 26 to June 28.

LARVAL FEEDING PERIOD.

The duration of the larval feeding period of 46 individuals of *Altica chalybea* reared to adults varied from 19 to 33 days with an average of 24.26 days. The period covered by records of feeding larvæ extended from June 4, the earliest date of hatching, to July 20, the latest date, when larvæ entered the ground. Complete data on the larval feeding period are given in Table IV.

TABLE III.—*Incubation period of [illegible] eggs, [illegible] Park, Fla., 1917.*

Date of oviposition	Date of hatching	Number of eggs	Duration of period	Date of oviposition	Date of hatching	Number of eggs	Duration of period
			Days.				Days.
May 26	June 14	6	19	June 2	June 15	16	13
26	16	6	21	2	16	4	14
29	12	1	14	2	17	5	15
31	13	4	13	2	18	2	16
31	14	4	14	2	19	2	17
31	15	2	15	4	19	25	15
31	16	2	16	4	20	17	16
31	14	12	13	13	28	1	15
June 1	15	4	14				
1	16	1	15			[1] 108	[2] 15.18

[1] Total. [2] Weighted average.

DURATION OF FIRST LARVAL STAGE.

The duration of the first stage, of 68 larvæ reared, varied from 4 to 14 days with an average of 8.74 days, as is shown in Table V. The total period covered by records on larvæ in this stage extended from June 4 to July 2.

TABLE IV.—*Time and duration of larval feeding period of A. chalybea, North East, Pa., 1917.*

Date of hatching.	Date of entering ground.	Number of larvæ.	Duration of period.	Date of hatching.	Date of entering ground.	Number of larvæ.	Duration of period.
			Days.				*Days.*
June 4	June 28	2	24	June 17	July 8	3	21
12	July 1	1	19	17	10	1	23
13	4	2	21	17	11	1	24
13	5	1	22	19	10	3	21
13	8	4	25	19	11	4	22
14	7	1	23	19	13	3	24
14	8	2	24	19	14	1	25
14	9	2	25	19	20	1	31
14	17	1	33	20	15	2	25
15	11	2	26	20	17	4	27
15	13	2	28	20	20	1	30
16	8	1	22				
16	10	1	24			[1] 46	[2] 24.26

[1] Total. [2] Weighted average.

DURATION OF SECOND LARVAL STAGE.

The duration of the second stage, of 60 larvæ reared, varied from 5 to 11 days with an average of 6.95 days, as shown in Table VI. The total period covered by records on larvæ of this stage extended from June 9 to July 8.

TABLE V.—*First larval stage of A. chalybea, North East, Pa., 1917.*

Number of larvæ.	Duration of stage.
	Days.
1	4
2	5
1	6
8	7
26	8
9	9
8	10
10	11
1	12
1	13
1	14
[1] 68	[2] 8.74

[1] Total. [2] Weighted average.

DURATION OF FEEDING PERIOD OF THIRD LARVAL STAGE.

The duration of the feeding period of the third stage, of 47 larvæ reared, varied from 5 to 13 days with an average of 8.53 days, as is shown in Table VII. The total period covered by records on larvæ of this stage extended from June 15 to July 20.

DURATION OF PERIOD IN GROUND.

The duration of the period in the ground varied from 15 to 25 days with an average of 19.24 days. The total period covered by records on the immature stages in the ground and emergence are given in full in Table VIII.

DURATION OF PREPUPAL PERIOD.

The duration of the prepupal period, of 23 individuals recorded, varied from 7 to 13 days with an average of 9.17 days, as shown in Table IX. The period covered by records on prepupæ extended from June 28, when the first larvæ entered the ground, to July 24, when the latest transformed to pupæ.

DURATION OF PUPAL PERIOD.

The duration of the pupal period of 17 individuals recorded varied from 7 to 10 days with an average of 8.47 days, as shown in Table X. Records on this stage extended from July 17 to 31.

DURATION OF CALLOW PERIOD.

The duration of the callow period of the adult stage varied from 1 to 4 days with an average of 2 days. The records are summarized in Table XI. Records on this period extended from July 24 to August 4.

SUMMARY.

There is only one generation annually, winter being passed in the adult stage. Beetles emerge from hibernation when the grape buds are swelling and oviposition begins soon after and continues until about the middle of June, a few days before the latest adults disappear.

The average duration of the incubation period in 1917 was 15.18 days.

The larval feeding period averaged 24.26 days in 1917. Records of feeding larvæ began June 4 and continued until July 20. The duration of the different larval stages was as follows: First stage, 8.74 days in 1917; second stage, 6.95 days in 1917; third stage, 7.75 days in 1916 and 8.53 days in 1917.

TABLE VI.—*Second larval stage of A. chalybea, North East, Pa., 1917.*

Number of larvæ.	Duration of stage.
	Days.
3	5
18	6
26	7
8	8
3	9
1	10
1	11
[1] 60	[2] 6.95

[1] Total.
[2] Weighted average.

The duration of the period in the ground averaged 20.71 days in 1916 and 19.24 days in 1917. Records taken during the two years on the transformations of this beetle while in the ground extended from June 22 to August 4. The duration of the different stages in the ground in 1917 was as follows: Prepupa 9.17 days, pupa 8.47 days, callow adult 2 days.

TABLE VII.—*Feeding period of third larval stage, A. chalybea, North East, Pa., 1917.*

Number of larvæ.	Duration of stage.
	Days.
1	5
6	6
10	7
5	8
10	9
11	10
2	12
2	13
[1] 47	[2] 8.53

[1] Total.
[2] Weighted average.

THE LESSER GRAPEVINE FLEA-BEETLE.

(*Altica woodsi* n. sp.)

The specific name *A. woodsi* is given in recognition of Mr. Woods's recent systematic and biological studies of members of the genus Altica (*25*, *26*), and because he is the first to record what is probably this insect as a new species.

DESCRIPTION OF STAGES.

THE ADULT.

Pl. II, D.

This beetle is similar to *Altica chalybea*, from which it may be distinguished as follows: Color metallic green, rarely with purple or olivacious reflections; antennal joint 3 equal in length to joint 4; average length 3.05 mm., varying from 2.43 to 3.05 mm.

TABLE VIII.—*Time and duration of period in ground of A. sholybeus, North East, Pa., 1917.*

Date of entering ground.	Date of emergence.	Number of individuals.	Duration of period.	Date entering ground.	Date of emergence.	Number of individuals.	Duration of period.
			Days.				*Days.*
June 28	July 25	1	27	July 11	July 30	2	19
July 2	27	3	25	11	Aug. 1	1	21
4	26	2	22	13	July 31	2	18
5	26	1	21	13	Aug. 2	2	20
7	27	1	20	14	2	3	19
8	27	4	19	15	July 31	1	16
8	28	3	18	15	Aug. 1	1	17
9	30	1	21	15	3	1	19
10	28	1	18	17	1	3	15
10	29	1	19	17	4	1	18
10	30	3	20				
11	28	4	17			[1] 42	[2] 18.24

[1] Total. [2] Weighted average.

Described from a large series of beetles reared at North East, Pa., under Quaintance No. 16427.

Type.—Cat. No. 22290, U. S. National Museum.

THE EGG.

Pl. I, F.

Similar to that of *Alaus sholybeus*. Length 0.75 mm., width 0.35 mm. Color straw yellow. Brownish serosa much larger proportionately than that of the "large form," about one-half the length of the egg. The size and color are as described by Comstock [1].

TABLE IX.—*Prepupal period of A. sholybeus, North East, Pa., 1917.*

Number of prepupæ.	Duration of period.
	Days.
2	7
2	8
1	9
4	10
4	13
[1] 13	[2] 9.77

[1] Total. [2] Weighted average.

THE LARVA.

Pl. II, A.

Similar to the larva of the "large form" (*A. sholybeus*) but much smaller. The chitinized areas are smaller proportionately and the fully fed larva is distinctly yellow without the brownish color element. The setæ on the ventral prothoracic segment are wanting. Width of head: First instar from 0.292 to 0.312 mm., average 0.304 mm.; second instar from 0.448 to 0.468 mm., average 0.455 mm.; third instar 0.577 to 0.624 mm., average 0.612 mm. Average length of full grown larva 5 mm.

THE PUPA.

Pl. II, B.

The writer knows of no characteristic by which this pupa may be distinguished from that of its larger relative except that of size. The average length is 4.5 mm.

TABLE X.—*Pupal stage of A. sholybeus, North East, Pa., 1917.*

Number of pupæ.	Duration of period.
	Days.
4	7
4	8
7	9
3	10
[1] 17	[2] 8.47

[1] Total. [2] Weighted average.

TABLE XI.—*Adult period of adult stage of A. sholybeus, North East, Pa., 1917.*

Number of individuals.	Duration of period.
	Days.
1	1
1	2
2	3
1	4
[1] 5	[2] 2

[1] Total. [2] Weighted average.

DISTRIBUTION.

The writer has collected this species in the vicinity of North East and Moorheadville, Pa., and has observed it at Niagara Falls, N. Y.

FOOD PLANTS.

The grape (*Vitis* spp.), both wild and cultivated, and the Virginia creeper (*Parthenocissus quinquefolia*) are food plants of both the larva and the adult of this beetle. Of the cultivated grapes the larva flourishes on thin-leaved varieties like the Delaware but does not favor thick-leaved sorts like the Concord. Larvæ were frequently found on Concord grapes in the field but the majority of the newly hatched larvæ placed on Concord leaves in cages failed to pass the first instar. After this instar was passed little difficulty was experienced in carrying them to the adult stage.

Grape growers, mentioned by Slingerland (*19*), who stated that thin-leaved varieties of grapes were preferred by the grapevine flea-beetle probably had this insect to deal with instead of the typical species.

HABITS.

When the adult emerges from hibernation in the spring it attacks grape leaves which are already expanded. On the leaves of favored hosts it feeds on the lower sides, riddling them with holes. (Pl. IV.) On Concord and other similar varieties it feeds on the upper surface, pitting it with short irregular feeding marks but not eating through the leaf. (Pl. III, C.) Like the typical species it feeds much more voraciously at this time than later. It also has the same habit of feigning death when alarmed.

Eggs are usually placed singly on the underside of grape leaves, along the veins. (Pl. I, C.) Occasionally two or three are together and very rarely they are on the upper surface of the leaves. This is strikingly different from the place of oviposition and arrangement of eggs described by Slingerland (*19*) and Hartzell (*24*), but agrees with the records of Comstock (*12*), Marlatt (*18*), and others.

Like the adult the larva usually feeds on the underside of thin-leaved varieties of grapes and the Virginia creeper. A newly hatched larva usually begins at the side of a leaf vein and bores upward. When leaves are first attacked a series of small holes appears along the leaf veins, producing a characteristic marking which need not be mistaken for the feeding injury of any other insect. (Pl. IV.) After feeding has progressed for some time the holes are larger and are scattered over the leaf, which may become entirely skeletonized. The larvæ do not move readily from one leaf to another and consequently the leaves on one part of the vine may be completely riddled while those near by are untouched.

On leaves of the Concord grape and similar varieties the larva feeds on the upper surface, leaving narrow, irregular, chainlike feeding marks, much narrower and less continuous than those of the larger species. On these varieties there is also a great tendency for the larva to feed on leaf veins and in the flower cluster.

Its manner of passing the pupal period and its relation to temperature are very similar to those of the larger species.

TABLE XII.—*Incubation period of A. woodsi, North East, Pa., 1916.*

Date of oviposition.	Date of hatching.	Number of eggs.	Duration of period.
			Days.
June 10	June 23	2	13
10	25	4	15
10	26	2	16
10	27	1	17
15	27	2	12
15	28	3	13
15	30	5	15
25	July 7	9	12
26	7	12	11
		[1] 40	[2] 12.82

[1] Total. [2] Weighted average.

LIFE HISTORY.

EMERGENCE FROM HIBERNATION AND OVIPOSITION IN 1916.

Adults were first noted in 1916 on May 29 and appeared in abundance at that time. Beetles were copulating on the day when first observed and this was continued intermittently as long as beetles of this generation were found on the vines. Oviposition was first noted on June 6 and continued until after the middle of July.

INCUBATION.

The incubation of eggs recorded in 1916 required from 11 to 17 days with an average of 12.82 days, as shown in Table XII.

TIME AND DURATION OF THE LARVAL FEEDING PERIOD OF ALTICA WOODSI, NORTH EAST, PA., 1916.

Forty-one larvæ were carried through the larval feeding period from the date of their hatching to the date of their entering the ground. The duration of this period varied from 13 to 27 days, with an average of 18.71 days. The period covered by records on feeding larvæ extended from June 18 to July 26. Complete data on the time and duration of this period are given in Table XIII.

TABLE XIII.—*Time and duration of larval feeding period of A. woodsi, North East, Pa., 1916.*

Date of hatching.	Date of entering ground.	Number of larvæ.	Duration of period.	Date of hatching.	Date of entering ground.	Number of larvæ.	Duration of period.
			Days.				*Days.*
June 18	July 7	1	19	June 26	July 15	1	19
18	10	1	22	28	21	2	23
20	10	2	20	29	15	4	16
21	10	1	19	30	18	1	18
22	19	1	27	30	24	1	24
23	10	5	17	July 1	24	1	23
23	12	1	19	4	17	1	13
24	10	3	16	4	21	4	17
24	12	1	18	8	21	2	13
25	17	5	22	8	26	1	18
25	18	1	23				
26	14	1	18			[1] 41	[2] 18.71

[1] Total. [2] Weighted average.

DURATION OF FIRST LARVAL STAGE.

The duration of the first stage, of 74 larvæ reared, varied from 3 to 9 days with an average of 6.16 days, as shown in Table XIV.

TABLE XIV.—*First larval stage of A. woodsi, North East, Pa., 1916.*

Number of larvæ.	Duration of stage.
	Days.
1	3
1	4
17	5
32	6
16	7
3	8
4	9
[1] 74	[2] 6.16

[1] Total.
[2] Weighted average.

TABLE XV.—*Second larval stage of A. woodsi, North East, Pa., 1916.*

Number of larvæ.	Duration of stage.
	Days.
4	4
18	5
15	6
11	7
14	8
2	10
1	15
[1] 65	[2] 6.46

[1] Total.
[2] Weighted average.

The records in this stage cover a period from June 18, the earliest recorded date of hatching, to July 15, the latest recorded date of passing the first molt.

DURATION OF THE SECOND LARVAL STAGE.

The duration of the second larval stage varied from 4 to 15 days with an average of 6.46 days, as shown in Table XV. The total period covered by records on larvæ of this stage extended from June 25 to July 21.

TABLE XVI.—*Feeding period of third larval stage of A. woodsi, North East, Pa., 1916.*

Number of larvæ.	Duration of period.
	Days.
2	3
2	4
9	5
12	6
7	7
1	8
4	9
3	10
1	13
[1] 41	[2] 6.51

[1] Total.
[2] Weighted average.

DURATION OF FEEDING PERIOD OF THIRD LARVAL STAGE, NORTH EAST, PA., 1916.

The duration of the feeding period of the third stage of 41 larvæ varied from 3 to 13 days, with an average of 6.51 days, as shown in Table XVI. The total period covered by records of larvæ in this stage extended from July 1 to 26.

DURATION OF PERIOD IN GROUND.

The period in the ground includes the prepupal period, which is the latter part of the third stage, the pupal period, and the early part of the adult stage before emergence from the pupal cell. Fifty-three individuals were carried through this period. The minimum time required was 14 days, the maximum 21 days, and the average of 16.15 days. The period covered by these records extended from July 7, when the first larva entered the ground, until August 29, when the last adult emerged. These data are given in full in Table XVII.

TABLE XVII.—Time and duration of hibernation stages of the grapevine flea beetle, North East, Pa., 1917.

Date of emergence from hibernation	Period of emergence	Number of days	Number of beetles	Total number of beetles	Time of emergence	Number of beetles emerging	Duration of hibernation
June 1	May 19 to June 1	13	1	1	May 19	1	Days. 182
	June 1 to June 15	15	1	2	June 1	1	195
	June 15 to June 29	15	1	3	June 15	1	209
	June 29 to July 13	15	1	4	June 29	1	223
	July 13 to July 27	15	1	5	July 13	1	237
	July 27 to Aug. 10	15	1	6	July 27	1	251
	Aug. 10 to Aug. 24	15	1	7	Aug. 10	1	265
	Aug. 24 to Sept. 7	15	1	8	Aug. 24	1	279
	Sept. 7 to Sept. 21	15	1	9	Sept. 7	1	293
	Sept. 21 to Oct. 5	15	1	10	Sept. 21	1	307
				10		10	2,441

[1] Total. [2] Weighted average.

EMERGENCE FROM HIBERNATION, 1917.

A few beetles emerged from hibernation in the latter part of May, but they were not abundant until the early part of June. The first specimens were collected May 19 on wild grape, when Concord grape shoots were about 8 inches long and the flower buds were showing. None were collected on cultivated grapes until June 3, when they were common. They increased in numbers until about June 9.

TABLE XVIII.—Incubation period of A. vitidis, North East, Pa., 1917.

Date of oviposition.	Date of hatching.	Number of eggs.	Duration of period.
July 19	July 3	1	Days. 15
20	4	1	15
21	5	1	15
22	6	1	15
23	7	1	15
24	8	1	15
25	9	1	15
26	10	1	15
27	11	1	15
28	12	1	15
29	13	1	15
		11	165
			[2] 15.72

[1] Total. [2] Weighted average.

OVIPOSITION.

Oviposition began about 18 days after the emergence of the earliest adults and continued until the latter part of July. The latest recorded date of oviposition was July 28. The longest recorded period of oviposition for a single female was 41 days, from June 12 to July 28; this beetle deposited eggs on 17 days during that period. The number of eggs deposited by four isolated females varied from 57 to 181, with an average of 102.3 eggs each. Thirty-one eggs is the largest number deposited on a single day.

INCUBATION.

The duration of the incubation period of 71 eggs varied from 13 to 15 days, with an average of 15.72 days, as shown in Table XVIII.

TIME AND DURATION OF THE LARVAL FEEDING PERIOD.

The duration of the feeding period of 190 larvæ varied from 15 to 23 days with an average of 18.59 days. The period covered by records on feeding larvæ extended from June 26 to July 26. Complete data on time and duration of this period are given in Table XIX.

TABLE XIX.—*Time and duration of larval feeding period of A. woodsi, North East, Pa., 1917.*

Date of hatching	Date of entering ground	Number of larvæ	Duration of period	Date of hatching	Date of entering ground	Number of larvæ	Duration of period.
			Days.				*Days.*
June 26	July 14	5	18	July 4	July 25	2	21
26	15	6	19	5	22	2	17
26	16	1	20	5	23	7	18
26	17	11	21	5	24	2	19
July 2	20	6	18	5	25	3	20
2	21	7	19	6	23	3	17
3	21	9	18	6	25	7	19
3	22	15	19	7	23	6	16
3	23	9	20	7	24	3	17
3	24	3	21	7	25	1	18
3	25	1	22	9	24	2	15
3	26	1	23	9	25	1	17
4	22	9	18	9	26	1	12
4	23	24	19				
4	24	5	20			[1]190	[2]18.59

[1] Total. [2] Weighted average.

DURATION OF THE FIRST LARVAL STAGE.

The duration of the first larval stage was from 4 to 11 days with an average of 6.35 days, as shown in Table XX. The period covered by records on larvæ of this stage extended from June 26, the earliest recorded date of hatching, to July 15, the latest recorded date of passing the first molt.

TABLE XX.—*First larval stage of A. woodsi, North East, Pa., 1916.*

Number of larvæ	Duration of stage.
	Days.
2	4
29	5
85	6
74	7
39	8
4	9
3	10
1	11
[1]237	[2]6.35

[1] Total.
[2] Weighted average.

DURATION OF SECOND LARVAL STAGE.

The duration of the second stage of 209 larvæ was from 4 to 9 days with an average of 6 days, as shown in Table XXI. The total period covered by records on larvæ of this stage extended from July 1 to July 21.

DURATION OF FEEDING PERIOD OF THIRD LARVAL STAGE.

The duration of the feeding period of the third larval stage of 189 larvæ varied from 4 to 9 days with an average of 6.62 days, as shown in Table XXII. The total period covered by records of larvæ in this stage is from July 6 to July 26.

TIME AND DURATION OF PERIOD IN GROUND.

The duration of the period in the ground of 141 individuals reared varied from 12 to 17 days with an average of 14.01 days. This period is surrounded by records extending from July 14 to August 11. The data on time and duration of this period are given in full in Table XXIII.

TABLE XXI.—*Second larval stage of A. mendica, North East, Pa., 1903.*

Number of pupæ	Duration of period
1	12 days.
2	13 days.
4	14 days.
3	15 days.
1	16 days.
1	17 days.
12	Total.

TABLE XXII.—*Feeding period of third larval stage of A. mendica, North East, Pa., 1903.*

Number of larvæ	Duration of period
1	5 days.
1	6 days.
3	7 days.
4	8 days.
2	9 days.
1	10 days.
12	Total.

DURATION OF PUPAL STAGE.

The pupal period of 43 individuals recorded varied from 6 to 9 days, with an average of 7.14 days, as shown by Table XXV. The total period covered by records on the pupæ extended from July 20 to August 7.

TABLE XXIV.—*Time and duration of period in ground of A. mendica, North East, Pa., 1903.*

Date of entering ground.	Date of emergence.	Number of individuals emerging.	Duration of period.	Date of entering ground.	Date of emergence.	Number of individuals emerging.	Duration of period.
July 14	July 26	1	12 days.	July 14	July 26	1	12 days.
15	27	1	12 days.	15	27	1	12 days.
16	28	1	12 days.	16	28	1	12 days.
17	29	1	12 days.	17	29	1	12 days.
18	30	1	12 days.	18	30	1	12 days.
19	31	1	12 days.	19	31	1	12 days.
20	Aug. 1	1	12 days.	20	Aug. 1	1	12 days.
21	2	1	12 days.	21	2	1	12 days.
22	3	1	12 days.	22	3	1	12 days.
23	4	1	12 days.	23	4	1	12 days.
24	5	1	12 days.	24	5	1	12 days.
25	6	1	12 days.	25	6	1	12 days.
26	7	1	12 days.	26	7	1	12 days.
27	8	1	12 days.	27	8	1	12 days.
28	9	1	12 days.	28	9	1	12 days.
29	10	1	12 days.	29	10	1	12 days.
30	11	1	12 days.	30	11	1	12 days.
31	12	1	12 days.	31	12	1	12 days.
Aug. 1	13	1	12 days.	Aug. 1	13	1	12 days.
2	14	1	12 days.	2	14	1	12 days.
3	15	1	12 days.	3	15	1	12 days.
4	16	1	12 days.	4	16	1	12 days.
5	17	1	12 days.	5	17	1	12 days.
6	18	1	12 days.	6	18	1	12 days.
7	19	1	12 days.	7	19	1	12 days.
8	20	1	12 days.	8	20	1	12 days.
9	21	1	12 days.	9	21	1	12 days.
10	22	1	12 days.	10	22	1	12 days.
11	23	1	12 days.	11	23	1	12 days.
12	24	1	12 days.	12	24	1	12 days.
13	25	1	12 days.	13	25	1	12 days.
14	26	1	12 days.	14	26	1	12 days.
15	27	1	12 days.	15	27	1	12 days.
16	28	1	12 days.	16	28	1	12 days.
17	29	1	12 days.	17	29	1	12 days.
18	30	1	12 days.	18	30	1	12 days.
19	31	1	12 days.	19	31	1	12 days.
20	Sept. 1	1	12 days.	20	Sept

DURATION OF CALLOW PERIOD.

The duration of the callow period of the adult stage, or the period after transformation of the pupa to adult and before its emergence from the ground, was recorded for 48 individuals. It varied from 1 to 4 days, with an average of 2.19 days, as shown in Table XXVI. The period covered by these records extended from July 28 to August 11.

Table XXIV.—*Prepupal stage of A. woodsi, North East, Pa., 1917.*

Number of individuals.	Duration of period.
	Days.
29	4
12	5
7	6
2	7
[illegible]	[illegible]

[illegible]

SUMMARY.

The seasonal history of the lesser grapevine flea-beetle is similar in general to that of the larger species, but it is later throughout. There is a single generation annually, winter being passed in the adult stage. Beetles emerge from hibernation in the latter part of May or early June, some time after the grape shoots have expanded, or about three weeks later than the typical species. Oviposition begins early in June and continues until the latter part of July, when the last adults disappear.

The average duration of the incubation period was 12.82 days in 1916 and 13.72 days in 1917, slightly less than that of the larger species, but this difference may be accounted for by the fact that these incubation records were taken later in the season, when the temperature was higher.

Table XXV.—*Duration of pupal stage of A. woodsi, North East, Pa., 1917.*

Number of pupæ.	Duration of stage.
	Days.
[illegible]	6
[illegible]	7
[illegible]	8
2	9
[illegible]	[illegible]

[illegible]

[1] Total. [2] Weighted average.

Table XXVI.—*Callow period of adult stage of A. woodsi, North East, Pa., 1917.*

Number of individuals.	Duration of period.
	Days.
12	1
[illegible]	2
[illegible]	3
[illegible]	4
[illegible]	[illegible]

[illegible]

[1] Total. [2] Weighted average.

Larvæ are found on the vines in midsummer, the records of collection extending from June 18 to August 8. The average duration of the larval feeding period was 18.71 days in 1916 and 18.59 days in 1917, or about one-fourth shorter than that of the "large form." The duration of the three larval stages was as follows: First stage, 6.16 days in 1916 and 6.35 days in 1917; second stage, 6.46 days in 1916 and 6 days in 1917; third stage, 6.51 days in 1916 and 6.62 days in 1917.

The maximum limits of records of individuals transforming in the ground were from July 7 to August 29. The duration of this period of transformation averaged 16.15 days in 1916 and 14.50 days in 1917, or about 5 days less in each season than those required for the "large form." The average duration of the different stages in the ground was as follows: Prepupa 4.68 days, pupa 7.24 days, callow adult 2.19 days.

After emergence from the ground the beetles feed until late in autumn and then go into hibernation. A comparison of the foregoing with the seasonal history of the typical grapevine flea-beetle shows that the lesser species appears in the vineyard about three weeks later than the other and continues later throughout the season. The typical species disappeared from vineyards at the season indicated by Slingerland (19), while the "small form" was present at the time that the "tardy individual," referred to by him, was found ovipositing, some time after the overwintering adults of the typical species had disappeared. Following Slingerland's suggestion a little further, it seems probable to the writer that the collection of beetles of the "small form," if confused with the typical species, could easily give rise to the two-brood hypothesis.

This comparison also shows that the lesser grapevine flea-beetle is more rapid in its development, particularly in the larval and prepupal stages. This more rapid development can not be attributed to any extent to the fact that the larvæ appear later in the season, for even late individuals of the "large form" reared at the same time as the early individuals of the "small form" required more time for their metamorphosis.

ECONOMIC IMPORTANCE.

The grapevine flea-beetle, according to all accounts, has been one of the most destructive of insects to the grape industry. Slingerland (19) wrote in 1898 that for several years previous it had done more damage to vineyards in New York than all other grape insects combined. Emerging from hibernation at the time when the grape buds are swelling, a single beetle, by eating out comparatively few buds, destroys as many shoots and a much larger number of clusters. If the injury is repeated, according to Quaintance and Shear (22), the vines themselves may be weakened or killed. Feeding after the grapes come into leaf, either by the adults or by the larvæ, is less destructive.

Compared with its larger relative, the lesser grapevine flea-beetle is greatly limited in its possibilities for destructiveness because the adult does not emerge from hibernation early enough to attack the buds, but, like the larva, is strictly a leaf feeder. In spite of this limitation, however, where it occurs in large numbers it can cause

considerable damage by its skeletonizing of the foliage. In one instance the writer has noted the killing of 1-year-old vines of the Delaware variety by repeated defoliation. Not the least important economic consideration with regard to this beetle is the possibility of its being mistaken for the larger form and the consequent confusion of remedial measures.

In spite of their potential ability to injure the grape industry, during the years of the writer's residence in the Erie-Chautauqua grape belt (1914–1917) both of these insects were of minor importance. Such infestations as were observed were confined to vines on the borders of vineyards adjacent to woodlands in which there were heavy growths of wild grapes.

The grapevine flea-beetle, like a number of related insects, is given to sporadic outbreaks of destructiveness followed by periods of comparatively little economic importance. This is well illustrated by the periodic receipt of complaints by the Bureau of Entomology. Based on this source of information, it appears that there have been three distinct extensive outbreaks in recent years: One in 1892 in Michigan, Missouri, Iowa, and Kansas, one during 1894 and 1895 in New York, and one in 1911 in Maryland, Virginia, and the District of Columbia. Requests for information regarding this insect have been received in practically all of the intervening years, but they have been comparatively few in number and much more local. Slingerland (*19*), writing in 1898, also records a serious period of destructiveness in New York for several years previous. On the other hand, 17 years later Hartzell (*24*) estimated that in the Erie-Chautauqua grape region less than 1 per cent of the area was infested.

It is probable that the period when the writer's observations were made represented a low tide in the abundance of these beetles, due to natural checks, as they were totally absent not only in vineyards where measures to destroy them might be taken, but also from the majority of neglected vineyards and from most growths of wild grapes. But aside from the natural causes there are two other factors which have contributed to a permanent change in the economic status of this pest. Poison sprays, applied primarily to destroy the grapevine rootworm (*Fidia viticida* Walsh) and the grape-berry moth (*Polychrosis viteana* Clem.), readily destroy the flea-beetle larvæ feeding on the leaves at that time and may destroy many of the adults of the lesser flea-beetle which are also still in the vineyards. Up-to-date methods of tillage under vines, which break open the pupal cells, are also a contributing factor. These two factors make it difficult for beetles to reproduce in well-cared-for vineyards and limit them to neglected vineyards and wild vines. Sporadic outbreaks may nevertheless be expected in vineyards adjacent to favorable breeding places, and these may be very severe locally.

PREDATORY ENEMIES.

The natural causes responsible for the periods of comparative unimportance of the flea-beetles at the time they were under observation were undetermined. Three species of carabid beetles and one of ants were found predatory on both flea-beetles, although none of the carabids was found in large numbers. No species of parasites has been reared by the writer.

Lebia viridis Say,[1] the most common carabid, was closely associated with both species of flea-beetles. It feeds upon the eggs, larvæ, and pupæ of both species. This Lebia, although classed as a ground-beetle, is largely arboreal. It was found in leaf mold under wild grapevines, where flea-beetles were pupating in large numbers, but more frequently on grape leaves, both in vineyards and on wild vines. One specimen was taken on a wild grapevine over 15 feet above the ground. In spite of their individual voracity, as these beetles always occurred singly and were never found in large numbers, they were not regarded as of sufficient importance to hold the grapevine flea-beetles in check.

The earliest recorded collection of *Lebia viridis* was May 22, in 1917. This beetle was found feeding upon eggs under strips of bark on grape canes. No more were found until June 22, when larvæ of the typical flea-beetle were quite common on the vines. After this time until the first of August *Lebia viridis* was fairly numerous. The latest record of collection was September 11, in 1916, after all of the immature stages of the flea-beetles had transformed.

This carabid is steel blue in color and about the size of the typical grapevine flea-beetle, with which it might be confused by a casual observer. It is probably the enemy of the flea-beetle referred to by Hartzell (24), which he describes as a "carabid closely resembling the adult flea-beetle in size and color."

Lebia ornata Lec.[1] and *Harpalus erythropus* Dej.[1] were found in very small numbers in leaf mold under wild grapevines, and fed upon pupæ and prepupæ of the flea-beetles in confinement.

A brown ant, *Myrmica scabrinodis* Nyl., subsp. *schencki* Emery, var. *emeryana* Forel,[2] destroyed a large amount of larval and pupal material that was intended for use in rearing work. Full-grown larvæ had been placed in earth in flowerpots partially buried in the insectary yard. A few days later ants were found carrying larvæ and pupæ from these pupation quarters.

The Biological Survey has found grapevine flea-beetles in the stomachs of the following birds: Bobwhite (*Colinus virginianus*), meadowlark (*Sturnella magna*), Cape May warbler (*Dendroica tigrina*), red-eyed vireo (*Vireosylva olivacea*), white-eyed vireo (*Vireo griseus*),

[1] Determined by Mr. E. A. Schwarz. [2] Determined by Dr. W. M. Wheeler.

Philadelphia vireo (*Vireosylva philadelphica*), Carolina wren (*Thryothorus ludovicianus*), and bluebird (*Sialia sialis*).

METHODS OF CONTROL.

As previously stated, no extensive infestation of either species of flea-beetle came under the writer's observation in the Erie-Chautauqua grape belt, and those infestations that did occur were confined to vines at the ends of rows or the edges of vineyards.[1] In such situations hand-picking the beetles was the best means of control. The effect of this method is immediate, which is very desirable against so voracious an insect, against which arsenical sprays act comparatively slowly. On small areas in a corner or at the edge it is also cheaper than the employment of a power sprayer, which must be drawn the entire length of each row, of which only a small part may be infested. Had an extensive infestation occurred, spraying would have been resorted to, but as none was present no spraying experiments were conducted.

The application of a spray mixture containing 3 pounds of arsenate of lead paste (1½ pounds, powdered) to 50 gallons of Bordeaux mixture is usually recommended for the control of the typical species. One of the recent investigators, Hartzell (*24*), states that this mixture protects the vines from severe injury because it is repellent to the beetles and disperses them over the vineyard, but that it does not kill them. To kill the beetles he has found that a high dosage of arsenate of lead, not less than 4 pounds paste (2 pounds, powdered) to 50 gallons of water, is most effective. This high dosage is necessary to kill the beetles quickly before much damage is done, because of their voracity and resistance to poison. He also states that the effectiveness of the poison is much increased by the addition of one-half gallon of molasses to the foregoing mixture. The addition of molasses because of its solubility has the disadvantage, however, of making the poison likely to be washed off by rains. Owing to the frequency of rains at this season of the year this is a very serious disadvantage. *Molasses should not be added to a spray solution containing Bordeaux mixture, or burning of the foliage is apt to result.* The time of application should be on the first warm day when the grape buds are swelling, or as soon as the beetles appear.

The difficulty of destroying the adults makes it important that these pests be not allowed to reproduce in a vineyard. The

[1] After this paper had gone to press, in the spring of 1920, the writer's attention was called to extensive destructiveness by *A. chalybea* at Neosho, Mo., by Mr. F. W. Faurot, director of the Missouri State Fruit Experiment Station at Mountain Grove, Mo. It was stated that the greater part of the crop in a number of vineyards had been destroyed by the activities of this beetle during the previous season. In 1920 it was apparently much the most destructive grape insect of the region. Spraying experiments for the control of beetles emerging from hibernation were conducted by Mr. A. J. Ackerman and the writer, in cooperation with the Missouri Fruit Experiment Station. Arsenate of lead at the rate of 3 pounds (powdered) to 50 gallons of water gave fair control, and this dosage was much more effective than one of 2 pounds to 50 gallons of water.

immature stages are very susceptible to remedial measures, and their destruction incidental to good tillage and to spraying for the control of other pests has been referred to under the discussion of economic importance (p. 20–21). The regular spray applications for the control of the grapevine rootworm and the grape-berry moth are so timed that they are entirely effective against the larvæ of *Altica woodsi* but can not be relied upon to destroy all of the larvæ of *A. chalybea*. During both 1916 and 1917 the earliest larvæ of the latter species began entering the soil about 10 days before the first regular spray application was made. In case of a heavy infestation of larvæ of this species on the grape foliage an application made just before the grapes bloom is advisable to prevent a heavy infestation of beetles the following spring. This extra application, however, probably will be rarely necessary.

GENERAL SUMMARY.

The grapevine flea-beetle (*Altica chalybea* Ill.) is a grape pest which eats out the swelling buds in early spring, thus destroying the embryonic shoots and fruit clusters. Later both the beetles and the larvæ feed upon leaves of the grape. It is single brooded. Winter is passed in the adult stage. Eggs are deposited in groups under bud scales or strips of bark; the larvæ migrate to the leaves to feed and enter the soil to pupate; and the pupæ transform to the adult stage by early summer. This is in agreement with the habits and seasonal history as usually described in the literature of the species.

Statements that the eggs are deposited on leaves, that the insect is two-brooded, and that it prefers thin-leaved varieties of grapes as hosts rather than the Concord variety, are due to a confusion with a closely allied species, the lesser grapevine flea-beetle (*Altica woodsi* n. sp.), hitherto usually determined as "*A. chalybea*, small form." This insect is also single brooded but emerges from hibernation enough later in the season to appear as a second brood of the typical species. Eggs are deposited singly, or sometimes in a cluster of two or three on the underside of the leaf upon which they feed. As in the case of the first-named species, transformations are passed in the ground and winter is passed in the adult stage.

In addition to the above-mentioned characteristics, the lesser grapevine flea-beetle may be distinguished from its larger ally by its distinctly smaller size in all stages, by the green color of the adult instead of blue, the pale yellow of the egg instead of a deep yellow or orange, the yellow body color of the larva instead of a brownish yellow, and the absence of setæ on the ventral prothoracic plate of the larva. The feeding marks of both larva and adult are also a ready means of identification. Both the adult and the larva of the

lesser species merely pit the upper surface of thick-leaved varieties of grapes, and eat small holes in the foliage of thin-leaved varieties. Both stages of its larger ally strip the leaf tissue of varieties like the Delaware, while on leaves of varieties like the Concord the larva makes large whitish patches on the upper surface, and the adult, also feeding on the upper surface of the leaves, eats large holes in them.

Almost no other insect can cause as severe injury to the grape crop, in restricted areas, as that of which the grapevine flea-beetle is capable when the grape buds are swelling. The lesser species, which emerges later, is less destructive. Both species are sporadic in their occurrence from season to season and they are now restricted in their distribution largely to vineyards adjacent to wild grape arbors. A number of predatory enemies, of which *Lebia viridis* Say is the most important, contribute to its natural control.

Where vineyards are liable to injury from this pest, vigilance in early spring is essential to safety. When the beetles do appear their voracity makes prompt action necessary. If, as is usually the case, the infestation covers only a small area, hand-picking the beetles will probably be the most effective as well as the cheapest means of control, while if a large area is infested, spraying with arsenate of lead will probably be necessary. A spray application of 3 pounds of arsenate of lead paste (1½ pounds powdered) is ordinarily recommended, but if the infestation is severe and rains can be avoided, a dosage of not less than 6 pounds of arsenate of lead paste (or 3 pounds powdered) to 50 gallons of water may be used. The larvæ of the lesser species and most of those of the larger species may be readily destroyed by the usual spray applications for the grape-berry moth and the grapevine rootworm, and these measures, together with up-to-date vineyard tillage, make it practically impossible for these pests to reproduce in a vineyard and limit them to wild vines. Very rarely a spray application before the grapes bloom will be advisable to destroy the earliest larvæ of *A. chalybea*. These measures have probably been the cause for the change in the economic status of the grapevine flea-beetle from apparently a first-rate pest of 20 years ago to one of second-rate importance at present.

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